Application No. 10/671,851
Appeal Brief dated July 27, 2007

RECEIVED
CENTRAL FAX CENTER
JUL 27 2007

121850-1

I hereby certify that this paper is being Facsimile transmitted to the Patent and Trademark Office on the date shown below. The central facsimile number is 1-571-273-8300.

(Signature) | 7/27/07 (Date of Facsimile) | (18 pages, plus 1 page transmittal)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: M. R. Jackson et al. : Group Art Unit: 1742

Application No.: 10/671,851 : Examiner: Jessee R. Roe

Filed: September 26, 2003

For: HIGH-TEMPERATURE COMPOSITE ARTICLES AND ASSOCIATED METHODS OF MANUFACTURE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPEAL BRIEF UNDER 37 C.F.R. 41.37

(i) Real Party in Interest

General Electric Company is the real party in interest.

07/30/2007 SFELEKE1 00000059 070868 10671851
01 FC:1402 500.00 DA

(ii) Related Appeals and Interferences

None

(iii) Status of Claims

Claims 1, 3, 5-21, 23, 25 and 27-43 were initially pending, and claims 22 and 24 had previously been withdrawn from consideration. Claims 1, 3, 5-21, 23, 25 and 27-43 were subject to a final rejection, based on the Patent Office Action of November 28, 2006. On April 27, 2007, Appellant appealed the rejection of those claims.

Claims 1, 3, 5-21, 23, 25 and 27-43 are pending, and are being appealed.

(iv) Status of Amendments

No amendments have been filed subsequent to the final rejection of November 28, 2006.

(v) Summary of Claimed Subject Matter

In the embodiment represented by claim 1, a method of forming a refractory metal-intermetallic composite (RMIC) is described. As described in paragraph 3 of the specification, these materials, exemplified by the niobium-silicide alloys, provide an unusual combination of properties. The materials can withstand very high temperatures – much higher than traditional nickel-based superalloys. Moreover, the ductile metal phase (Nb-based) and the relatively brittle intermetallic phase (often Si-based) provide a very useful combination of mechanical properties over a wide range of temperatures. (See paragraph 3 of the specification). These properties include low-temperature toughness and high-temperature strength and creep-resistance. For these reasons, the RMIC's are especially suited for use in demanding applications like gas turbine engines.

While RMIC's have tremendous potential, their manufacture can be extremely difficult. As described in paragraph 4 of the specification, the typical

thermo-mechanical forming, casting, and solidification techniques cannot always be used with RMIC materials which have such high melting temperatures. For example, extrusion temperatures of about 1450°C-1650°C are required, with minimal dimensional change. Moreover, the complex chemistry and high reactivity of these alloys make microstructural control difficult to achieve, resulting in a greater incidence of defective castings.

In the embodiment which is the basis for claim 1, the serious processing problems are addressed by a partitioning step, in which a first powder of a refractory metal suitable for forming a metal phase is blended with a second powder containing a silicide precursor suitable for forming an intermetallic phase (page 4, paragraph 12 of the specification). The first powder comprises at least one of niobium, titanium, and molybdenum, and the second powder comprises at least one of silicon, germanium, and boron (page 4, paragraph 13).

After the blending/partitioning step, the powder blend is consolidated and mechanically deformed at a prescribed temperature. (See page 6, paragraph 16 of the specification). As recited in claims 12 and 13, and more fully described in paragraph 16, the lower-temperature consolidation and deformation step is carried out at a temperature which minimizes the formation of the silicide component, so as to avoid cracking. Other important advantages of carrying out this step at relatively low temperatures are described in paragraph 17 of the specification.

The third step set forth in claim 1 requires a higher-temperature reaction to thermally treat the consolidated and deformed powder. As set forth in claims 15 and 16, the thermal-treatment step is preferably carried out at a temperature greater than that required for the silicide reaction, e.g., greater than about 1,050°C. As set forth in page 7, paragraphs 18 and 19, this step results in the formation of the desired metal/intermetallic phase structure, i.e., one which provides a prescribed balance of mechanical and environmental properties.

Claim 23 is directed to a method for forming an article from an RMIC material. The method comprises the steps of blending first and second powders which contain at least one of niobium/titanium/molybdenum and

silicon/germanium/boron, respectively ("Nb/Ti/Mo and Si/Ge/B"). This step is followed by the consolidation/deformation step at a first temperature, and then the powder blend-reaction step at a second, higher temperature. Claims 34, 35, 37 and 38 recite temperature parameters for the two last-mentioned steps.

(vi) Grounds of Rejection to be Reviewed on Appeal

Whether claims 1, 3, 5-9, 23, 25, and 27-39 are patentable under 35 U.S.C. 103, in view of U.S. Patent 6,692,586, issued to Xu et al ("Xu").

Whether claims 12-17 are patentable under 35 U.S.C. 103, in view of U.S. Patent 6,692,586 ("Xu").

Whether claims 10-11 and 32-33 are patentable under 35 U.S.C. 103, in view of U.S. Patent 6,692,586, ("Xu") and U.S. Patent 4,836,849, issued to Svedberg et al ("Svedberg").

Whether claims 18-20 and 40-42 are patentable under 35 U.S.C. 103, in view of U.S. Patent 6,692,586, ("Xu") and U.S. Patent 6,428,910, issued to Jackson et al ("Jackson").

Whether claims 19-21 and 41-43 are patentable under 35 U.S.C. 103, in view of U.S. Patent 6,692,586, ("Xu") and U.S. Patent 4,836,849 ("Svedberg").

Whether the claims of this Application are subject to a Double Patenting Rejection.

(vii) Argument

Rejection of Claims 1, 3, 5-9, 23, 25, and 27-39 as Obvious, in View of Xu

As detailed above, claim 1 includes the following steps:

1) blending a first powder of at least one of Nb/Ti/Mo with a second powder of at least one of Si/Ge/B;

2) consolidating and mechanically deforming the powder blend at a selected temperature; and

3) reacting the resulting powder blend at a second, higher temperature, to form the 2-phase metallic/intermetallic composite.

Xu describes high-temperature braze materials, which contain one or more base elements such as Ti, Ta, Nb, Hf, Si, and Ge (element symbols used here). The compositions also include a secondary element selected from Cr, Al, Nb, B, Si, Ge, and mixtures thereof. (See col. 4, lines 9-26). The constituents are combined to form a braze composition, i.e., a lower-melting composition used to join articles made from higher-melting structural materials, like the RMIC's. While the composition of Xu may contain some elements which happen to be similar to some elements of the present invention, the overall braze material has nothing to do with the present invention. Moreover, Xu fails to disclose or suggest the mechanical deformation/reactions steps for the refractory metal/silicide precursor, as in the present claims.

Furthermore, Xu also fails to suggest the higher-temperature reaction step recited in claim 1, wherein the metal-intermetallic phases are formed. Certainly, the Xu compositions are heated at some point (e.g., Example 1, bottom of column 9, regarding vacuum arc melting). However, it appears that most of the heating steps in the reference are in no way similar to Applicant's powder blend-reaction step. They instead simply relate to heating steps as part of the brazing process, (col. 8, lines 55-65; and Examples 2-4). When two different temperature levels are incorporated into the process (col. 8, line 65 to col. 9, line 10, it has nothing to do with preparation of an RMIC. It is simply a heating scheme to form a brazed, diffusion bond. The use of a "foil" (as noted by the Examiner) is also directed only to the brazing of adjacent layers, regardless of how the foil is "heat-treated" (see col. 7, lines 37-49).

Rejection of Claims 12-17 as Obvious, in View of Xu

Claims 12-17 are directed to temperature parameters which are preferred in certain embodiments, as described above. For example, the first temperature treatment is less than that required for the silicide reaction to begin, e.g., less than about 1,050°C; while the second temperature is greater than that required for the silicide reaction to begin, e.g., greater than 1,050°C. As described previously, there are specific advantages to these temperature specifications.

While Xu generally describes heating steps, the specific heating limitations in claims 12-17 are never suggested by the reference. Moreover, the <u>reason</u> for selecting the temperature levels, e.g., prevention or allowance of silicide formation, are also never suggested by the reference. Any implication regarding heating at two different temperature levels relates only to a heating schedule for brazing.

<u>Rejection of Claims 10-11 and 32-33</u>
<u>Under 35 U.S.C. 103, in View of Xu and Svedberg</u>

While the techniques involved in the consolidation/deformation steps of these claims are known in the art, their application to RMIC materials based on Nb/Ti/Mo and Si/Ge/B, according to the step-sequence of claim 1, are never suggested. Svedberg describes oxidation resistant niobium alloys. The materials are shaped and formed by mechanically alloying a powdered niobium alloy with powdered intermetallic compounds. The preparation steps involve intimately mixing the constituents, and altering the particle size distribution, and then forming the resulting material into a desired shape. (See col. 1, lines 48-55). The mechanical alloying-step can be carried out by a variety of techniques, such as ball-milling. The composition can then be formed into a desired shape by a consolidation technique such as hot pressing, explosive bonding, and the like. The shape can be coated with an oxidation-resistant coating (col. 3, lines 25-42). The materials appear to be directed to combinations of niobium with aluminum, iron, cobalt, or chromium (col. 2, lines 43-46).

While Svedberg contains some steps which are similar to those of the present invention, the reference fails to describe the consolidation-

deformation/reaction steps for a refractory-silicide composition, as in the present invention. As mentioned previously and described in the specification, the presence of the silicide phase is critical for providing a specific combination of strength and oxidation resistance over a wide-ranging temperature environment. (While Svedberg happens to mention certain "silicides", as in column 3, lines 35-40, it is only in reference to coatings which are applied over the niobium alloy part).

In regard to Applicant's other pending claims, Svedberg certainly mentions some of the individual elements in the alloys, but fails to describe silicide-based RMIC's which include such elements. It is also not clear as to whether Svedberg suggests Applicant's specific temperature/time schedules. Moreover, Svedberg fails to suggest the preparation of the graded composite recited in claim 18. As described in paragraph 13 of the specification, the claimed process can be used to incorporate property gradients into a shaped part, so that different sections of the part have different attributes. Svedberg contains no suggestion of such a concept.

Rejection of Claims 18-20 and 40-42 Under 35 U.S.C. 103, Xu and Jackson

The Xu reference has been discussed previously, and the distinctions set forth in those sections are also relevant to the grading concept of claims 18 and 40, as well as the protective coating/TBC layers of the other claims present in this rejection. The Jackson patent describes specific types of RMIC composites, based on a combination of elements, including Nb, Si, Ta, Ti, and Hf, as well as other elements (col. 3, lines 33-38). The composites include a core and an overlying surface layer (col. 3, lines 56-63). A general description of the preparation of the alloys is provided in column 6, lines 8-19.

While Jackson certainly describes niobium silicide composites, the reference never suggests the processing steps of the present invention. The preparation description provided in column 6 is a general teaching which does not address the problems which prompted the discovery of the present invention.

In regard to the use of Jackson for a teaching of a "graded composition", Applicant notes that there are distinctions here as well. Jackson only describes a graded surface layer. (col. 3, lines 25-29; col. 4, lines 33-41; claim 29). The reference never describes the preparation of a graded composite by a sequence of specific deformation/reaction steps, as in the present invention.

Rejection of Claims 19-21 and 41-43
Under 35 U.S.C. 103, Based on Xu and Svedberg

It appears to be the Examiner's contention that these two references make these claims obvious, because of their description of various coatings over the article, as well as the use of a ball-milling technique in the consolidation/deformation step. While similar coatings and techniques may be alluded to in the references, these claims contain limitations present in independent claims 1 and 23, respectively. Those limitations are never suggested by the references, as discussed previously. Thus, when the Examiner submits that it would be "...obvious...to modify the method...", Applicant must emphasize that the initial method was never suggested in the first place.

The Double Patenting Rejection.

Claims 23, 25, and 27-43 have been objected to , as being a substantial duplicate of claims 1, 3, and 5-21. While Applicant believes that there are distinctions between the two sets of claims, cancellation of the second set, without prejudice, would be entertained if the first set is deemed allowable.

Respectfully submitted,

By 7/27/07

Francis T. Coppa
Reg. No. 31,154
General Electric Company
Building K1, Room 3A67
One Research Circle
Niskayuna, New York 12309

Telephone: (518) 387-7530

RECEIVED
CENTRAL FAX CENTER
JUL 27 2007

(viii) Claims Appendix

1. A method for forming a refractory metal-intermetallic composite, the method comprising:

providing a first powder comprising a refractory metal suitable for forming a metal phase;

providing a second powder comprising a silicide precursor suitable for forming an intermetallic phase;

blending the first powder and the second powder to form a powder blend;

consolidating and mechanically deforming the powder blend at a first temperature; and

reacting the powder blend at a second temperature to form the metal phase and the intermetallic phase of the refractory metal-intermetallic composite, wherein the second temperature is higher than the first temperature; and

wherein the first powder comprises at least one of niobium, titanium, and molybdenum; and the second powder comprises at least one of silicon, germanium, and boron.

3. The method of claim 1, wherein the first powder comprises niobium, titanium, and hafnium.

5. The method of claim 1, wherein the second powder comprises silicon, chromium, and aluminum.

6. The method of claim 1, wherein the refractory metal-intermetallic composite comprises titanium, hafnium, silicon, chromium, and niobium.

7. The method of claim 1, wherein the refractory metal-intermetallic composite comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, between about 5 atomic percent and about 25 atomic percent silicon, between about 1 atomic percent and about 14 atomic percent chromium, and a balance of niobium, based upon the total composition.

8. The method of claim 1, wherein the refractory metal-intermetallic composite comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, up to about 10 atomic percent tantalum, between about 5 atomic percent and about 25 atomic percent silicon, up to about 6 atomic percent germanium, up to about 12 atomic percent boron, between about 1 atomic percent and about 14 atomic percent chromium, up to about 4 atomic percent iron, up to about 4 atomic percent aluminum, up to about 5 atomic percent tin, up to about 3 atomic percent tungsten, up to about 3 atomic percent molybdenum, and a balance of Niobium, based upon the total composition.

9. The method of claim 1, wherein the refractory metal-intermetallic composite comprises silicon, germanium, and boron, together comprising between about 5 atomic percent and about 25 atomic percent of the refractory metal-intermetallic composite, iron and chromium, together comprising between about 1

atomic percent and about 18 atomic percent of the refractory metal-intermetallic composite.

10. The method of claim 1, wherein consolidating the powder blend comprises consolidating the powder blend using a technique selected from the group consisting of cold isostatic pressing, hot isostatic pressing, hot pressing, explosive consolidation, magnetic pulse consolidation, ram pre-extrusion consolidation, hot forging, hot swaging, and hot extrusion.

11. The method of claim 1, wherein mechanically deforming the powder blend comprises mechanically deforming the powder blend using a technique selected from the group consisting of cold extrusion, hot extrusion, cold forging, hot forging, cold rolling, hot rolling, cold swaging, and hot swaging.

12. The method of claim 1, wherein the first temperature is less than that required for a silicide reaction to begin.

13. The method of claim 1, wherein the first temperature is less than about 1,050 degrees C.

14. The method of claim 13, wherein the first temperature is maintained for a time of less than about 2 hours.

15. The method of claim 1, wherein the second temperature is greater than that required for a silicide reaction to be complete.

16. The method of claim 1, wherein the second temperature is greater than about 1,050 degrees C.

17. The method of claim 16, wherein the second temperature is maintained for a time of more than about 4 hours.

18. The method of claim 1, wherein the refractory metal-intermetallic composite has a graded composition.

19. The method of claim 1, further comprising disposing an environmentally-resistant coating on a surface of the refractory metal-intermetallic composite.

20. The method of claim 1, further comprising disposing a thermal barrier coating on a surface of the refractory metal intermetallic composite.

21. The method of claim 1, further comprising using high-energy ball milling to achieve a coating of the first powder comprising the refractory metal on the second powder comprising the silicide precursor.

23. A method for forming a refractory metal-intermetallic composite article, the method comprising:

providing a first powder comprising a refractory metal suitable for forming a metal phase;

providing a second powder comprising a silicide precursor suitable for forming an intermetallic phase;

blending the first powder and the second powder to form a powder blend;

consolidating and mechanically deforming the powder blend at a first temperature; and

reacting the powder blend at a second temperature to form the metal phase and the intermetallic phase of the refractory metal-intermetallic composite article, wherein the second temperature is higher than the first temperature; and

wherein the first powder comprises at least one of niobium, titanium, and molybdenum; and the second powder comprises at least one of silicon, germanium, and boron.

25. The method of claim 23, wherein the first powder comprises niobium, titanium, and hafnium.

27. The method of claim 23, wherein the second powder comprises silicon, chromium, and aluminum.

28. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises titanium, hafnium, silicon, chromium, and niobium.

29. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, between about 5 atomic percent and about 25 atomic percent silicon, between about 1 atomic percent and about 14 atomic percent chromium, and a balance of niobium, based upon the total composition.

30. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises between about 15 atomic percent and about 30 atomic percent titanium, between about 1 atomic percent and about 8 atomic percent hafnium, up to about 10 atomic percent tantalum, between about 5 atomic percent and about 25 atomic percent silicon, up to about 6 atomic percent germanium, up to about 12 atomic percent boron, between about 1 atomic percent and about 14 atomic percent chromium, up to about 4 atomic percent iron, up to about 4 atomic percent aluminum, up to about 5 atomic percent tin, up to about 3 atomic percent tungsten, up to about 3 atomic percent molybdenum, and a balance of Niobium, based upon the total composition.

31. The method of claim 23, wherein the refractory metal-intermetallic composite article comprises silicon, germanium, and boron, together comprising between about 5 atomic percent and about 25 atomic percent of the refractory metal-intermetallic composite, iron and chromium, together comprising between about 1 atomic percent and about 18 atomic percent of the refractory metal-intermetallic composite.

32. The method of claim 23, wherein consolidating the powder blend comprises consolidating the powder blend using a technique selected from the group consisting of cold isostatic pressing, hot isostatic pressing, hot pressing, explosive consolidation, magnetic pulse consolidation, ram pre-extrusion consolidation, hot forging, hot swaging, and hot extrusion.

33. The method of claim 23, wherein mechanically deforming the powder blend comprises mechanically deforming the powder blend using a technique selected from the group consisting of cold extrusion, hot extrusion, cold forging, hot forging, cold rolling, hot rolling, cold swaging, and hot swaging.

34. The method of claim 23, wherein the first temperature is less than that required for a silicide reaction to begin.

35. The method of claim 23, wherein the first temperature is less than about 1,050 degrees C.

36. The method of claim 35, wherein the first temperature is maintained for a time of less than about 2 hours.

37. The method of claim 23, wherein the second temperature is greater than that required for a silicide reaction to be complete.

38. The method of claim 23, wherein the second temperature is greater than about 1,050 degrees C.

39. The method of claim 38, wherein the second temperature is maintained for a time of more than about 4 hours.

40. The method of claim 23, wherein the refractory metal-intermetallic composite article has a graded composition.

41. The method of claim 23, further comprising disposing an environmentally-resistant coating on a surface of the refractory metal-intermetallic composite article.

42. The method of claim 23, further comprising disposing a thermal barrier coating on a surface of the refractory metal intermetallic composite article.

43. The method of claim 23, further comprising using high-energy ball milling to achieve a coating of the first powder comprising the refractory metal on the second powder comprising the silicide precursor.

(ix) Evidence Appendix

None

(x) Related Proceedings Appendix

None

S.N. 10/671,851

RECEIVED
CENTRAL FAX CENTER
JUL 27 2007

121850-1

I hereby certify that this paper is being Facsimile transmitted to the Patent and Trademark Office on the date shown below. The central facsimile number is 1-571-273-8300.

(Signature) 7/27/07
(Date of Facsimile)

TRANSMITTAL OF APPEAL BRIEF

In re Application of:
Melvin Robert Jackson et al.

: Group Art Unit: 1742

Application No. 10/671,851

: Examiner: Jessee R. Roe

Filed: September 26, 2003

For: HIGH-TEMPERATURE COMPOSITE ARTICLES AND ASSOCIATED METHODS OF MANUFACTURE

To the Assistant Commissioner for Patents:

The $500.00 Appeal Brief fee is requested to be charged to Deposit Account No. 07-0868.

A fee of $120.00 for a One-Month Extension of Time is requested to be charged to Deposit Account No. 07-0868.

Please charge any other fees applicable to this application to the Deposit Account No. 07-0868.

Francis T. Coppa
Reg. No. 31,154

General Electric Company
Building K1, Room 3A67
Schenectady, New York 12301
Date: July 27, 2007
Telephone: (518) 387-7530

07/30/2007 SFELEKE1 00000059 070868 10671851
02 FC:1251 120.00 DA